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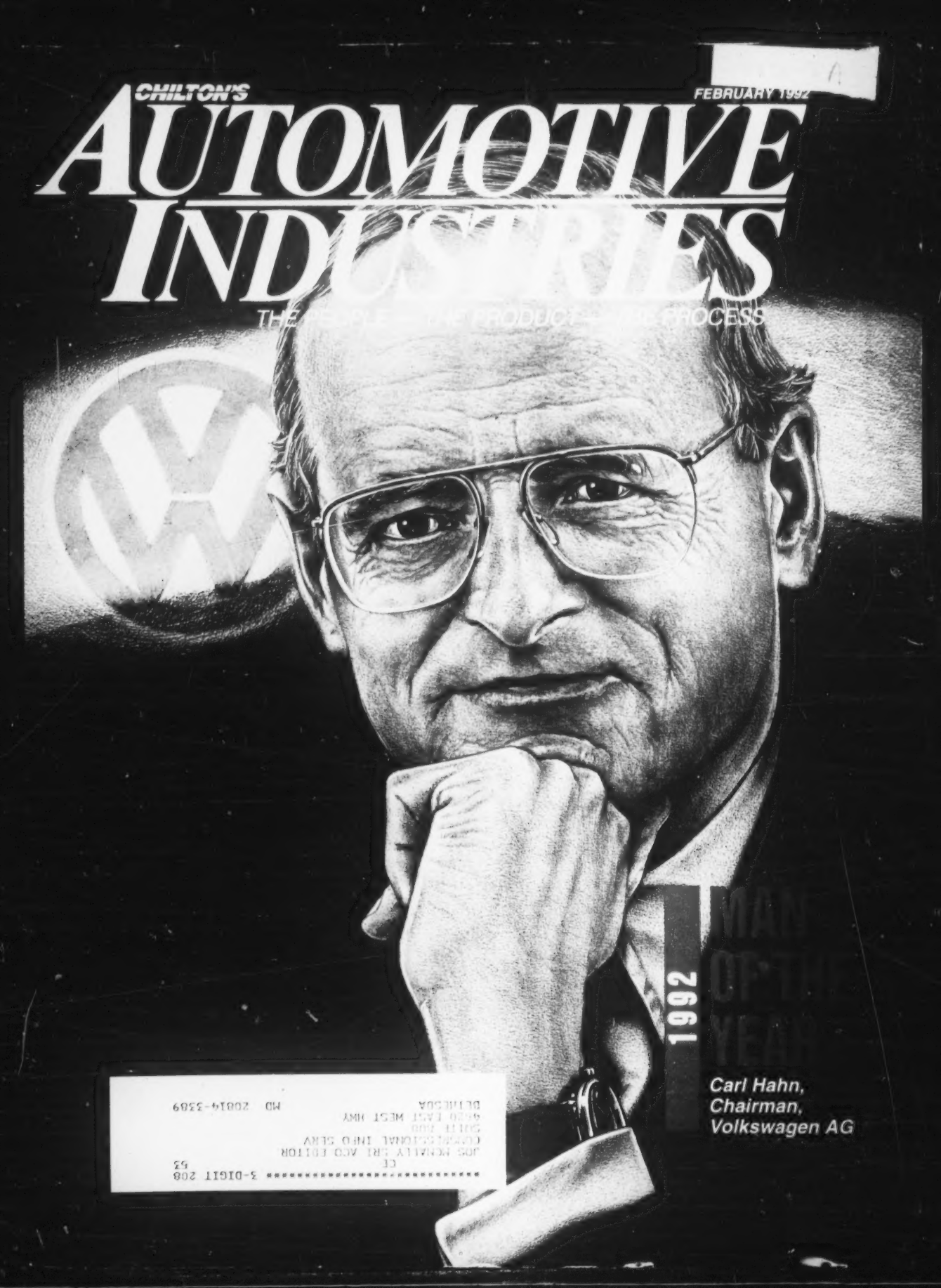

1992 MAN OF THE YEAR

Carl Hahn, Chairman, Volkswagen AG

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JOHN MCNALLY SRI ACD EDITOR
CLASSIFICATIONAL INFO SERV
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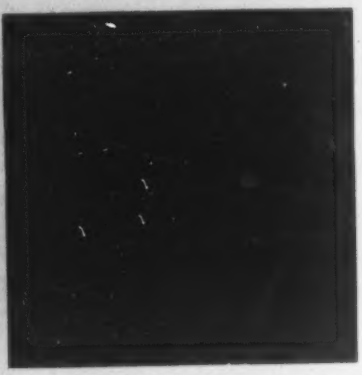

Dr. Carl Hahn is the architect of wholesale change at VW. Page 40. Cover portrait by Randy Hamblin

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1992 Man Of The Year **40**
Volkswagen's Carl Hahn leads an ambitious global strategy.

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by GERRY KOBE

ELECTRIC CAR UPDATE

California's new emission laws force automakers to re-invent the automobile.

The Federal Clean Air Act of 1990 and the latest regulations issued by the California Air Resources Board (CARB) proves the wisdom of an old saying: "Don't get too comfortable." For automakers, the new laws will tax R&D spending to the limit, dividing efforts between lower-polluting alternate-fuel vehicles, Low-Emissions Vehicles (LEVs), Ultra Low-Emissions Vehicles (ULEVs) and the ultimate in earth-conscious transportation, Zero-Emissions Vehicles (ZEVs).

CARB's ruling requires mandatory production of ZEVs, beginning with 2% of California's annual car sales in 1998, 5% in 2001, and rising to 10% by 2003. Automakers that sell fewer than 3000 units annually in the state are exempt from the law. Mid-volume manufacturers (3001-35,000 units annually) are exempt until 2003, but then must meet the 10% requirement.

CARB maintains that the law was necessary to support early efforts by automakers to produce electric models. And it based its decision on manufacturers' contentions that it requires a minimum 3000 units per year to make production of electrics feasible.

Meanwhile, a group of 12 Northeastern states have decided to copy California's new tougher standards—driving numbers even higher. Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania Rhode Island, Vermont and Virginia, along with Washington D.C., are already supporting the rules. In addition, decisions by Colorado, Louisiana, Oregon and Utah to adopt the standards are pending.

Combined registrations of California and the Northeast states represents 37% of the US car and light truck market. If all of the states considering the tighter standards decide to put them into effect, the number will jump to near 50%.

For automakers, ZEVs will be a key to survival.

"At present there are two accepted meth-

Citroën Citela

PSA Peugeot Citroën has been involved in electric vehicle R&D for over 20 years. Most of the company's efforts have involved conversion of conventional automobiles to electric for commercial fleet use. To that end, it hopes to sell 50,000 converted vehicles in MY 1995.

But the latest revolution from Citroën is the completely recyclable, electric-powered three-seat prototype Citela (City Electric Automobile).

Citroën Citela is designed for long-term use and ease of recycling.

Citela is based on a modular design that consists of a rigid rolling platform with a removable shell. The steel spaceframe is uniquely designed to take advantage of the structural integrity of the nickel-cadmium battery pack. It actually incorporates the pack to reduce flex and strengthen overall platform rigidity.

The car has interchangeable thermoplastic body panels that can convert it from coupe to small utility vehicle. All panels are easily removed to make conversions simple and promote ease of recycling.

Citroën intends the Citela to be durable enough for long-term use. The platform spec calls for one million kilometer durability, and batteries must exhibit a 10-year life. The car has a claimed top speed of 68 mph, and has a 68-mile range at an average 56 mph.

PSA Peugeot Citroën is currently participating in a government-sponsored program in France to evaluate the daily use of electric vehicles in an urban environment. In 1993, the Electric Company of France will equip the city of La Rochelle with public terminals where electric cars can be recharged. PSA Peugeot Citroën will provide 50 vehicles to select residents for evaluation.

ods of producing a ZEV vehicle—hydrogen and electric power. Hydrogen vehicles represent the most "familiar" alternative for consumers, but issues of safety, durability, driveability and packaging present bigger hurdles than can likely be cleared by the 1998 deadline.

The challenge in electric vehicles is small by comparison. The single biggest drawback lies in the development of a battery pack that will provide adequate range and quick recharge capabilities. And that issue is being jointly addressed by major automakers, battery manufacturers, utility companies, The Electric Power Research Institute (EPRI) and the Department of Energy (DOE).

The United States Advanced Battery Consortium (USABC) was established little more than one year ago, and has quickly established funding with the help of the DOE. The Big Three are business partners in the consortium, with the Electric Power Research Institute and DOE acting as non-business associates.

Last October, the DOE matched the consortium's funding levels on a one-to-one basis, placing the ABC's Phase One spending (through 1994) at $260 million. According to Roberta Nichols, Manager of Electric Vehicle External Associations for Ford and Secretary of the USABC, this is a major milestone in US automotive history. "This is the first time that government funding has happened with a goal of obtaining commercialization," says Nichols. "And it's a much bigger step away from [pure] research than any other relationship we've had previously. It will allow the technology to progress much faster than if any one of us had to do it

IMPLEMENTATION SCHEDULE FOR CARB STANDARDS

Model Year	TLEV .125	LEV .076	ULEV .040	ZEV .00	Fleet Avg. Standard
1996	20%				
1997		25%	2%		
1998		48%	2%	2%	
1999		73%	2%	2%	
2000		96%	2%	2%	
2001		90%	5%	5%	
2002		85%	10%	5%	
2003		75%	15%	10%	

Percentage requirements for ZEVs are mandatory

ESTIMATED ZEV VEHICLES REQUIRED BY CARB STANDARDS

Year	%	California and Northeast States	Pending States	Total ZEVs
1998	2	107,000	13,000	
2001	5	268,000	33,000	
2003	10	537,000	65,000	

Ford Connecta

Making its world debut at the 1992 Detroit Auto Show, Connecta is Ford's concept vision of the 'family taxi' of the future. It features bucket seats for four, with two additional rear-facing seats that pop out of the rear cargo area floor. Front passenger seat is equipped with an integral child seat.

For ease of entry, the vehicle has two center-opening doors (with no B-pillar) on the passenger side. The driver's side has a large single door. Beneath the skin, Ford uses a 330 V three-phase AC drive motor that combines both forward motion and braking functions into one compact unit. The motor is linked to a single-speed direct-coupled transaxle.

An electronic control module converts voltage from DC to AC and also regulates power from conventional charging and regenerative braking inputs. Connecta is fully multiplexed with a microprocessor-based controller monitoring all critical vehicle functions.

Battery technology is sodium-sulfur which has twice the energy storage capacity of lead-acid. Ford claims the combination of high power and low weight enables this car to approach the performance of conventional gasoline-powered vehicles.

Ford says the Connecta can be fully recharged overnight using conventional household current. Special 220 V outlets could reduce charge time by 40%.

Ford Connecta has sodium-sulfur batteries with twice the energy storage capacity of lead-acid.

alone." Right now, Nichols expects lead-acid batteries to power the first electric vehicles (EVs), but many viable challengers are on the horizon. Nickel-cadmium batteries offer an energy-hungry quick-charge capability, but can't hold a complete charge unless fully discharged, thus affecting vehicle range.

Lithium batteries are also under study, but temperature variations affect their energy release and reliability. Francois Castaing, vp—engineering at Chrysler, says lithium batteries hold a lot of promise long-term, and by 1995 the technology should be available for automotive use. Properly incorporated into the design, Castaing says lithium batteries could extend range to 300 miles.

On the horizon, sodium-sulfur could become the battery of choice. Compact and energy dense, it could ease packaging problems.

However, sodium-sulfur's chemical reaction releases large amounts of heat, and would require a unique recycling structure. Expense is also a problem. As we went to press, the consortium was still negotiating contracts with a number of companies con-

Nissan FEV

In response to the allegations that electric vehicles are not practical because of lengthy recharge times, Nissan is touting the world's fastest battery charging system. It's found in Nissan's FEV (Future Electric Vehicle) and Nissan claims it can achieve a 40% charge in six minutes! In addition, a 100% charge takes only 15 minutes.

The secret lies in FEV's 23 Nickel-Cadmium batteries which are very thin and lightweight (444 lbs). By using thinner and stronger separators than conventional units, surface area is increased, heat dissipation is improved and generating efficiency enhanced. Advanced materials also reduce electrical resistance.

The drawback to Nissan's quick charge system is that it would require 440V inputs to achieve its quick charging time. To accomplish this, the company acknowledges the need for an infrastructure with recharger units in shopping malls, office complexes, dealerships, etc.

The FEV uses two 20-kW motors driving the front wheels. It has an aluminum alloy floor and plastic body panels. The car is equipped with airbags and uses a heat-pump style air conditioner.

Nissan FEV boasts fastest charge time.

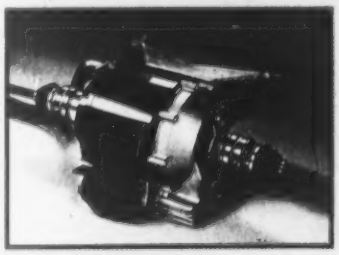
BMW E2

BMW's new E2 electric, which debuted at the 1992 L.A. Auto Show, is a larger, longer range version of the company's diminutive E1. BMW tailored the 2205-lb E2 toward Americans and American driving conditions. Its thermoplastic body, which rides on an extended E1 aluminum subframe, was styled by BMW's California studio, Designworks/USA.

The E2 carries more powerful batteries for a claimed 267-mile maximum range and 161-mile typical range. Claimed top speed is 75 mph, with 0-50 mph acceleration in 15.6 seconds. The E2 requires a 6 to 8 hour recharge.

Like all BMWs, the E2 is rear-wheel drive. Its electrons come from a large (over 450 lb) sodium-sulfur battery located underneath the rear seat. The battery powers a liquid-cooled, permanent magnet electric motor/differential designed and built by Unique Mobility Inc. of Englewood, CO.

The compact (14-in. diameter), 32-kW traction drive motor features a fairly flat torque and power curve—111 lb-ft and 45 hp—and operates through a BMW-designed single-speed gear reduction. Unique Mobility also designed and manufactures the cars' electronic controllers, also liquid-cooled. The BMW-Unique Mobility partnership began at the 1990 Detroit SAE show, and the E1/E2 project started in January 1991. Since building 50 of its own electric vehicles ('ElecTreks') in the 1970s, Unique Mobility has specialized in the development of electric motors and hybrid-powered vehicles including buses and military equipment. The company's motor technology is jointly owned by Alcan Aluminum.



Unique Mobility's permanent-magnet electric motor/differential is compact, liquid-cooled.

BMW E2 was styled by Designworks in California. Body is thermoplastic, some of it recycled material.

cerning 'best technology' for future-generation EVs.

This technology covers the entire vehicle, not just power systems.

Materials suppliers are proposing ultra-lightweight alternatives to plastic, steel and even aluminum. Carbon fiber is being widely considered, though breakthroughs in price and process would be needed for mass production.

Manufacturers of electrical components tout systems with low-draw characteristics. And power-and-signal distribution suppliers have developed low-resistance wiring and switchgear.

Glass that reduces solar load, tires with lower rolling resistance, LEDs, regenerative braking systems, heat pump technology, fiber optics and battery recharging systems are just a few of the technologies that are poised for explosive growth as electric vehicle production draws near.

Of course, the USABC is reluctant to share the details of this research before negotiations with these companies are completed. And its refusal to admit Japanese manufacturers stems from the members' belief that the US has the lead in electric vehicles, and should work to maintain that competitive advantage.

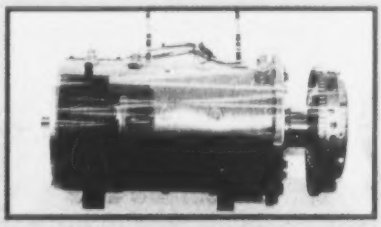
On paper, the notion that the US has a technological edge in electrics has some basis in fact. Projects like GM's Impact are well along toward the goal of mass production. But the European countries, particularly the UK, have a great deal of practical experience in producing and fielding electric vehicles.

As of 1989, the UK had approximately

Dodge EPIC

The Electric Powered Interurban Commuter (EPIC) is Chrysler's latest concept minivan. It utilizes the basic electric drivetrain from the company's TEVan program, a feasibility study which Chrysler vp of engineering Francois Castaing claims will be test marketed before the 1995 model year. "We are racing with the California 1998 regulations," Castaing says.

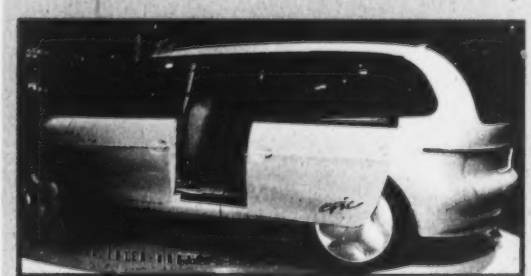
Like the TEVan, EPIC's 'juice' comes from a 180V/200 amp-hour nickel-iron battery pack mounted within the floorpan. The 1800-lb pack features an automatic watering system, good for three months between refills. If EPIC were in production today, the nickel-iron battery pack would cost Chrysler approximately $10,000, versus about $2000 for a comparable lead-acid battery pack, says Bob Davis, executive engineer for vehicle engineering.



Epic DC drive motor.

Chrysler worked jointly with General Electric in developing EPIC's 40-kW (56-hp) electric DC drive motor. It's a modified GE industrial unit, air/oil-cooled, which runs through a 2:1 reduction gear and separate clutch and two-speed automatic transaxle. The motor is set up to double as a generator during vehicle braking, giving EPIC regenerative braking. According to Davis, in a typical city driving cycle it will recover about 15% of electric power, says separate electric motor runs the vehicle's A/C system.

After traveling 120 miles (the SAE J227a C-cycle), the vehicle requires an eight-hour recharge on a residential-type 220V circuit. Top speed is a claimed 65 mph.



Dodge Epic uses nickel-iron battery technology. Current cost is five times lead-acid batteries.

TEPCO IZA

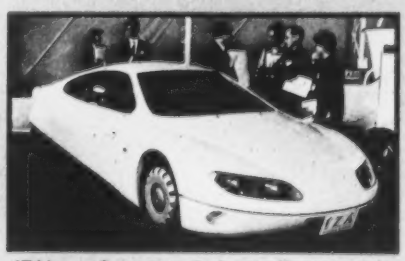
The IZA is a joint effort between Tokyo Electric Power Co. Inc. (TEPCO) and Tokyo R&D Co. Ltd. And if all claims for the vehicle are true, it represents Japan's best threat to GM's Impact.

IZA is a huge car by electric vehicle standards, measuring approximately 192 in. x 70 in. x 50 in., and weighing a hefty 3460 lbs. It seats four people comfortably.

The car features wheel-in-motor technology that puts a DC brushless motor at each front wheel. Claimed torque is a staggering 307 lb-ft. Power comes from a 288 V NiCad battery pack, with a lead-acid auxiliary battery to run accessories. Regenerative braking con serves power.

The most incredible aspect of the IZA is performance. Claimed acceleration for a standing quarter mile is about 18 seconds flat. The manufacturer claims a top speed of nearly 110 mph. Range on a fully charged set of batteries is said to exceed 340 miles at a constant 25 mph.

IZA's batteries will charge fully with an eight-hour charge cycle. Voltage to the charging unit is 200V at 50 amps.



IZA's performance is best effort yet from Japan.

Continued From Page 81

25,000 electrics on the road.

And many private companies in that country are accelerating their work on battery technology, particularly sodium-sulfur.

Japan has a small base of electric vehicles in operation (about 4000 in 1990), but has recently given priority status to developing more sophisticated cars. Japanese automakers are leaning toward nickel-cadmium batteries as a solution to quick charge and extended range.

Recyclability, though very much an issue with NiCad, is one the manufacturers feel they can solve before ZEVs are legislated into existence.

But many questions remain unanswered. Electric vehicles will be more expensive and less reliable than gasoline or alt-fuel vehicles.

And while government regulations may mandate 10% of the market by 2003, it's doubtful that consumers will willingly pay more money for a less versatile and less proven vehicle.

There is also a question among power companies that they will be able to meet the demand created by electric vehicles.

If additional powerplants have to be constructed, they will have to be clean.

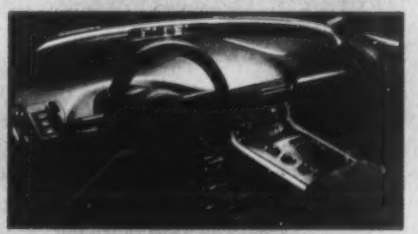
GM Impact

Impact's degree of development puts it well ahead of the pack in terms of being production-ready. But GM is still making changes to the fundamental vehicle.

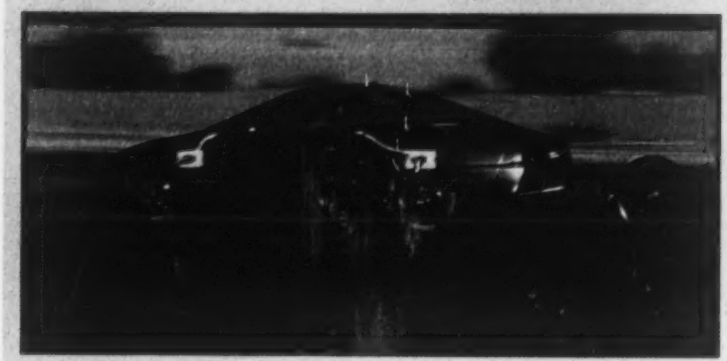
Recent improvements made to Impact's inverter have boosted reliability exponentially. And GM is said to be testing a version of Impact that uses a single motor instead of one at each front wheel. The single motor is in response to project engineers having problems synchronizing output of two motors, which creates a torque-steer effect.

A four-door version of Impact is also reported to be in the works, but on a different chassis than the coupe.

Sources close to the project say that power for the second-generation Impact will likely be lithium batteries, and not NiCad as originally planned. They also hint that Impact will be exported in its second year, and that provisions for right-hand drive are built into the car.



Impact interior is designed to convey 'electric' theme.



Impact has undergone more testing than any proposed electric vehicle.

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Continued From Page 83

And given current sentiments toward nuclear power, the solution may be impossible to achieve.

Still, electric vehicles represent an opportunity for US automakers to disrupt the momentum of its Japanese competition.

And that factor is reason enough for the Big Three to show very little resistance to California's laws.

To domestic manufacturers, ZEVs mean a one-time shot at leveling the playing field with Japan. Given that, electric vehicles are going to happen—ready or not. AI

Automotive Industries *staff members* ***John McElroy, editor-in chief; Lindsay Brooke, executive editor;*** *and* ***Christopher Sawyer, senior editor*** *contributed to this article.*

Ford Ecostar

Ecostar shares the same mechanicals with Ford's Connecta, but this ZEV already has a buyer. Ford has entered into an agreement with Detroit Edison to supply Ecostars to the utility beginning in early 1993.

Alan Gilmour, executive vp and president of Ford Automotive Group says, "Ecostars will be driven and used in real working environments for several years before we will be satisfied enough to make them available for sale. We are not going to put Ford vehicles on public sale until they have undergone durability and operational testing, and we are certain they meet quality and customer satisfaction standards."

Ford's Ecostar will be tested by Detroit Edison Co. in 1993.

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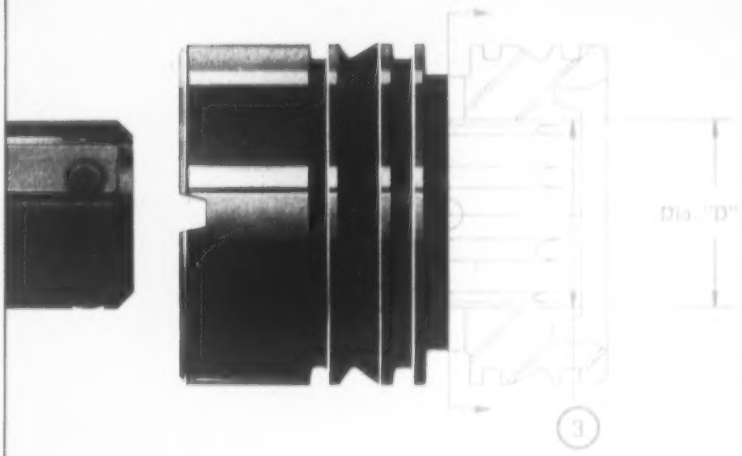

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IVHS

intelligent vehicle highway systems

An American's Tour Of Japanese IVHS

Japan will be the first nation to undertake widescale deployment of advanced driver information systems.

by JIM HAUGEN

This column is about a recent report entitled "An American Observation of IVHS in Japan" by Bob Ervin of The University of Michigan Transportation Research Institute (UMTRI). Ervin was part of a study mission to Japan in March of 1991. He was so impressed by what he saw he decided to document his findings in a formal report.

The importance of his report lies not just in his important personal conclusions, but also in his description of Japanese activities and the reasons behind their IVHS commitment. Especially insightful in his explanation of the forces supporting their commitment. He calls these "the 7 C's":

Congestion—Average vehicle speeds below 10 mph prevail through much of the daytime, even on expressways.

Conditioning—The Japanese government has 20 years of progress behind it in providing motorist information services, so motorists have come to expect continuing improvement.

Centralization—National highway construction and national traffic control are supplied by the Ministry of Construction and the National Police Agency, respectively.

Collaboration—Joint government/industry work in the IVHS area has been ongoing since 1973, with coordination by the Ministry of International Trade and Industry (MITI).

Customers—Executive buyers, who simply take "the full option package" in car purchases, provide an early market for automobile navigation systems, sparking industry competition.

Continuity—Their IVHS programs have been underway for almost 20 years, giving government and industry the opportunity to "learn by doing."

Cash—Japanese right-of-way is to expensive that stretching the serviceability of roadways through IVHS makes strong economic sense, so money is readily available.

The accompanying table, taken from the report, illustrates the importance of IVHS to the Japanese by comparing its road system to that of the US As shown, the Japanese road system is much less extensive. Even more important, this road network is distributed over a land area that's only 4% of the US, but serves a population half the size of the US.

In addition, traffic volume in Japan has tripled since 1970. US traffic volumes in the corresponding period have grown by a factor of 19. Japanese traffic fatalities in 1970 were also six or seven times the US rate, calling for drastic improvements in traffic control.

Their response to these problems has been to deploy the world's most extensive system of computer-controlled traffic signals at intersections. Some 411,000 intersections are currently under computer control. Groups of intersections are under the central command of sophisticated central traffic control centers which now exceed 160. An aggressive US Advanced Traffic Management System (ATMS) IVHS program might approach such numbers in the next 20 years.

The Japanese have also pursued a series of important Advanced Driver Information Systems (ADIS) programs with acronyms CACS, RACS, AMTICS and VICS. These programs have led the government to the verge of deployment of a national driver information system. However, they

Continued on Page 118

Comparison of the Japanese and US Road Systems

Road Type	Length of Road Systems in Japan Total Miles	Length of Road Systems in the US Total Miles	Length Ratios Japan/US
Expressways	2,700	45,000	
Primary Highways	29,000	259,000	
Prefecture (State)	80,000	49,000	
Local (County & City)	575,000	3,073,000	
Total	**686,700**	**3,876,000**	

(figures as of 1988)

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IVHS

Continued From Page 117

are now faced with significant deployment issues which will also arise in the US in the future. What is the best technology to standardize? Will a large number of users arise to buy such systems. How do you finance the roadside infrastructure required?

During 1991 MITI created an organization called the Association of Electronic Technology for Automobile Traffic and Driving. This organization has a 57-company membership and is pursuing a program called Super Smart Vehicle System (SSVS). SSVS is looking at ways to provide unusual levels of control assistance to drivers and covers similar ground to the US Advanced Vehicle Control System (AVCS) effort.

Because of the unique qualities of the needs of the Japanese road network, will the experience have only modest value in transferring elsewhere?

Due to the lack of tort liability concerns in Japan, they are expected to have a much easier time in implementing SSVS based safety systems with the public. Toyota is cited in the report as predicting that IVHS based safety systems will be in use in Japan by 1995, much faster than expected in the US.

Ervin concludes by raising the issue of transference of Japanese technology to the US environment. Because of the unique qualities of the needs of the Japanese road network, will the experience have only modest value in transferring elsewhere? Or will the knowledge gained be sufficiently generic that the Japanese applications work will provide a basis for worldwide IVHS leadership? Some good challenges to think about as we consider how aggressive the US should be in its IVHS efforts. AI